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Utilization of Google Earth to Identify Building Density

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Abstract

Land-use change is now common due to human activities, including economic, social, and cultural activities. Areas transforming for economic, social, and cultural purposes experience changes in land use, leading to a transition from green open spaces to buildings and resulting in hot daily surface temperatures due to a lack of vegetation. The purpose of this study is to examine the changes in built and non-built land in the Kartasura District. This study examines the relationship between surface temperature, vegetation, and building levels by using NDVI, NDBI, and ESG analysis, which is processed using the Google Earth Engine programming language. This study uses a qualitative descriptive method with a spatial approach, one of the approaches in the field of geography. The spatial approach in this study is more emphasized on spatial process analysis. The results indicate that there is a correlation between high surface temperature and low vegetation density, as well as high building density.

Keywords: *google earth engine, NDVI, NDBI, LST*

INTRODUCTION

Land-use change is a frequent phenomenon that is driven by various human activities, including economic development. As human activities grow and expand, green open spaces are transformed into buildings, which can have a positive impact on the economy by increasing the production of goods and services, thereby contributing to the prosperity of the community (Sukirno, 1994: 16).

The development of Surakarta City, which has not yet provided a role for the surrounding districts, will have a negative impact (Noviani et al., 2018). Negative impacts also occurred in Sukoharjo Regency, one of which was Kartasura District which is directly adjacent to Surakarta City (Widodo & Sunarti, 2019). Kartasura Subdistrict is a Local Activity Center (PKL) that functions as an urban area and as a center of activity and growth (Gulo, 2015) (Aini et al., 2022). The Regional Spatial Plan (RTRW) of Sukoharjo Regency for 2011-2031, is designated as a strategic area for several Kabupaten interests, one of which is the Fast Growing Strategic Area to increase economic growth Wilayah besides Grogol and Sukoharjo districts. Kartasura Subdistrict is included in the Strategic Area. Subosukawonosraten Urban Province.

(KSP) which is intended as a fast-growing provincial economy. One of the supporters of its designation as a fast-growing area is that there is a direction for industrial allotment areas which are the largest contributors to GRDP, namely 39.72%, in Kartasura District and are the basis for regional development (Anisah, et al., 2017: 2). The location of Kartasura Subdistrict which is in the meeting point of various regions, namely Boyolali,

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Karanganyar, Klaten, and Surakarta and is located at the node of transportation routes connecting three major cities, namely Surakarta, Semarang, and Yogyakarta make Kartasura a strategic area, this influences economic growth, Land-use, to population density in Kartasura District which has an area of about 1. 923 Ha, so Kartasura District is said to be a golden triangle area. Kartasura Subdistrict also has good prospects in the future for industrial, trade, service, and housing activities because it is close to airports and toll roads. Transportation has developed which has seen an increase in the function of the Kartasura terminal, the entry into force of bus-buses since 2009, and the existence of an inner-city bus garage in Ngabeyan Village, Kartasura District. In the facilities sector, residential areas began to grow in urban villages which on average were housing and built by developers, trade, and services also dominated along the main road and also had the second largest contribution after the industrial sector. Based on the explanation above, it can be known that there are changes that occur both physically, accessibility, and the economy in Kartasura District. The reality found is that every year there is a change in the use of agricultural land into residential land and its function is transferred to trade and service land. Major universities are also found in Kartasura, namely Raden Mas Said State Islamic University (UIN) and Muhammadiyah Surakarta University (UMS) as well as Transmart shopping centers that can boost the economy of the community in Kartasura District. Land conversion occurs precisely in agricultural land with high productivity into non-agricultural land (Novira et al., 2015). The conversion of land functions is a special attraction to be studied for changes. This condition is also related to the comfort of residing in Kartasura District. Urban vegetation can also enhance people's quality of life by connecting them with nature and increasing their level of comfort (Juniatmoko, 2021) (Nurdiana & Giyarsih, 2016).

Remote sensing technology, in combination with accessible GIS tools, can assist scientists and practitioners in comprehending the effects of environmental changes on species populations, ecosystem functions, and related support services. This aids in the exploration, analysis, and modeling of data (Purwanto & Andrasmoro, 2020) In GIS analysis, land classification can be carried out based on its designation (Sukuryadi & Wulandari, 2018) (Setyawan & Karmilah, 2017). Efforts to determine Land-use changes that occur in Kartasura Subdistrict can use the help of Google Earth Engine (GEE) technology through NDVI, NDBI, and ESG analysis by focusing on urban or developed areas is essential as they generally exhibit a greater reflection in the Shortwave Infrared (SWIR) region compared to the Near-Infrared (NIR) region. This approach is particularly valuable in monitoring and planning land use. The emphasis is on the high reflectance of SWIR in urban areas.

The function of Google Earth Engine is as a tool to analyze vegetation density, building density, and also surface temperature levels in an area. Google Earth Engine processes automatically using the javascript programming language which makes it easy for users to quickly perform a visual analysis. Google Earth Engine also has a variety of spatial data. Google Earth Engine is a cloud computing facility designed to store and process earthly big data (the amount of data is Petabytes, >1000 Terrabytes)

The use of Google Earth Engine compared to other applications can perform spatial data mining and spatial analysis simultaneously so that analysis becomes more effective and efficient (Hendargi, 2023) (Mukhoriyah et al., 2023). This research aims to identify alterations in the built and non-built land areas within the Kartasura District.

RESEARCH METHODS

This is a qualitative descriptive research with a spatial approach, one of the approaches in geography. The spatial approach in this study is more emphasized on the analysis of spatial processes (Putra, 2015).

1. Google Earth Engine

A developer platform for building and running web applications with hosting facilities on Google's servers Google Earth Engine combines the ability to analyze data at a planetary scale with access to a vast catalog of geospatial datasets and satellite imagery spanning multiple petabytes. This platform is utilized by researchers, scientists, and developers to monitor variations, observe patterns, and measure distinctions occurring on the Earth's surface.

Google Earth Engine is now accessible for commercial use, but it is still freely accessible for academic and research purposes. To obtain and

analyze data, Google Earth Engine implements a programming language. Citra Sentinel S2A Satelit. This study used sentinel S2A satellite imagery obtained through Google Earth Engine. The newly launched satellite imagery provides users with an alternative to obtaining imagery data with a fairly good spatial, temporal, radiometric, and spectral resolution when compared to SPOT and Landsat. In addition, Sentinel-2 can be downloaded for free and easily by the general public.

2. Analysis using programming languages Google Earth Engine:

a. Normalized Difference Vegetation Index (NDVI)

Determine the difference between near-infrared (which is strongly mirrored by vegetation) and red light to quantify vegetation (which is absorbed by vegetation).

The NIR and red bands are used in the formula for the Normalized Difference Vegetation Index (NDVI).

b. Normalized Difference Built Index (NDBI)

The emphasis is on urban or built-up areas which typically exhibit higher reflectance in the Shortwave Infrared (SWIR) region compared to the Near-Infrared (NIR) region (Macarof & Statescu, 2017). This application is extremely useful for land-use monitoring and planning. NDBI Equation:

c. Land Surface Temperature (LST) is the temperature on the earth's surface caused by the projection of objects captured by satellite imagery at a specific time. ESG can also be defined as the average surface temperature depicted in the scope of a pixel with a variety of different surface types.

The magnitude of the ESG value is influenced by the wavelength. The wavelength most sensitive to surface temperature is thermal infrared. However, basically, every wavelength will be sensitive to the response of temperature changes that affect the reflective value of the object. To be able to find ESG information, a process of identifying

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ground surface temperatures is carried out by utilizing thermal waves contained in satellite images.

RESULT AND DISCUSSION

1. Kartasura Region

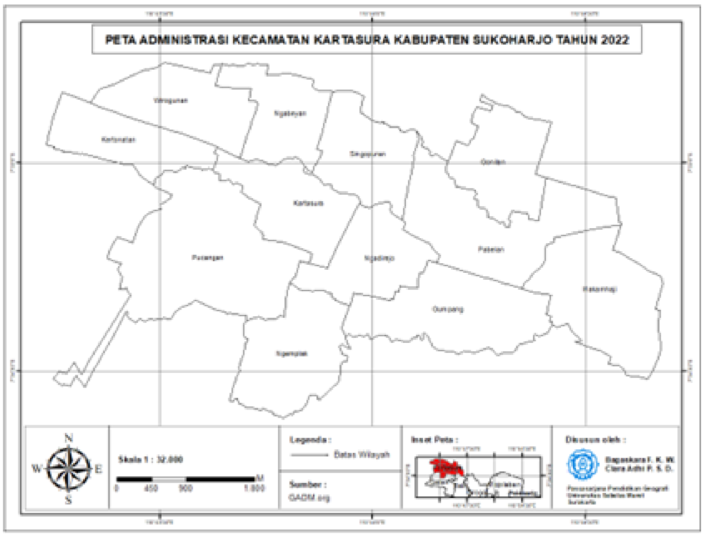

Figure 1. Kartasura Rural.

Kartasura region is an area bordering Surakarta City. However, this area includes the end of Sukoharjo Regency. To the north and east, it borders the Surakarta City area, the south borders Baki district and Klaten Regency, and the west borders Boyolali Regency.

Kartasura Subdistrict is located on the main road of solo–jogja and solo–boyolali routes. This area is also the northernmost area of Sukoharjo Regency. It has twelve villages including Pucangan, Wirogunan, Kertonatan, Kartasura, Ngemplak, Ngabeyan, Ngadirejo, Singopuran, Pabelan, Makamhaji, Gonilan, and Gumpang.

Kartasura Subdistrict has two other types of cover, namely built-up land and non-built land. The built land in Kartasura City consists of settlements, industrial buildings, and trading buildings. Non-built land in Kartasura District consists of rice fields which are green open spaces. Land cover in Kartasura Subdistrict is presented in table 1:

Table 1. Land Cover in Kartasura District in 2022

No	**Tutupan Lahan**	**Luas (a)**	**%**
1	Ruang Terbuka Hijau	439	21
2	Lahan Terbangun	1642	79
Total		2081	100

Sumber: (Badan Pusat Statistik, 2022)

Table 1 shows that the proportion of RTH in Kartasura District is 21% of the area. This shows that Kartasura District is still minimal regarding the availability of green open space. Kartasura Subdistrict is dominated by built-up land consisting of settlements, industry, and trade with a proportion of 79% of the area. The size of the built-up land

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encourages the heat of the surface in Kartasura District. The condition of Kartasura Subdistrict is in line with research conducted by (Rajkumar & Elangovan, 2020) Where green land is replaced by impermeable concrete covers and surfaces with high emissivity due to urbanization resulting in an increase in urban heat island.
Measurements in Kartasura Subdistrict use S2A Sentinel imagery. An overview of sentinel imagery is presented in Figure 2.

Figure 2. S2A Sentinel image (no scale).

Sentinel imagery was chosen in this study because this image has a good visual resolution of 60 m to perform an analysis. The Sentinel S2A image was launched in 2015. In this image, the latest image results with medium to high image resolution are able to be obtained.

2. NDBI

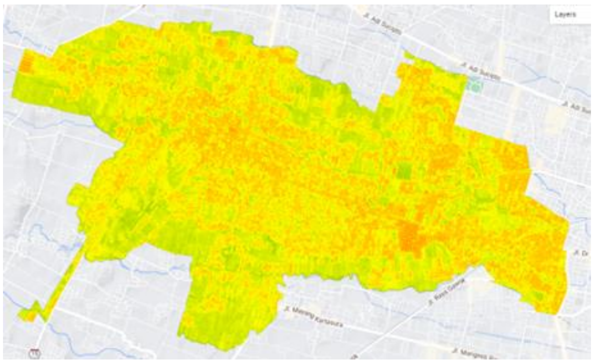

Figure 5. NDBI analysis (without scale)

In this NDBI analysis, it can be known the density of buildings based on color. The greener symbolizes vegetation or means the absence of buildings, and the yellow to reddish symbolizes the density of settlements. It is located in the central area of the main road kartasura.

Five of the twelve areas identified as having significant building density include Makamhaji, Gonilan, Pabelan, Gumpang, and Kartasura.

The density of buildings that occurs in Kartasura District begins with the existence of urban sprawl in Surakarta City so as to increase urbanization. Urbanization is also accompanied by an increase in population density, resulting in a high density of buildings as well. This condition is consistent with the findings of (Cui et al., 2016), (Du et al., 2020) who found that as a fundamental area of human activity, cities have a significant impacts on regional climate. Cities have a significant impact not only on regional land-use and land cover changes but also on the global climate.

CONCLUSION

Based on the analysis conducted using NDVI, NDBI and ESG, there is a relationship between high surface temperature and building density and high vegetation density. Surface High temperatures have something to do with low vegetation levels and high building density. Land change from vegetation to a building is inevitable over time. Through this article, in the future, they will be able to see and make it a study material for a policy that is beneficial to nature and humans. The implications of these findings are significant. The rapid urbanization and development in Kartasura District have resulted in environmental degradation, with negative impacts on the local climate, air quality, and overall livability of the area. The loss of green spaces and the increase in built-up areas can contribute to the urban heat island effect, leading to higher temperatures and reduced thermal comfort for residents. Additionally, the reduction in vegetation cover can impact biodiversity and ecosystem services, such as air purification and water regulation.

To address these issues, policymakers and urban planners should consider implementing sustainable urban development strategies that prioritize the preservation and expansion of green spaces, promote the use of eco-friendly building materials, and encourage the integration of nature-based solutions in urban design. This can help mitigate the negative impacts of land-use changes and contribute to the creation of more livable and resilient communities in the Kartasura District.

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